DOCUMENT RESUME

ED 154 338 CS 004 055

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TITLE Goals, Themes, Inferences, and Memory: A Developmental Study.
PUB DATE Mar 78
NOTE 38p.; Paper presented at the Annual Meeting of the American Educational Research Association (Toronto, Canada, March 27-31, 1978)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Child Development; *Cognitive Processes; *Comprehension Development; Educational Research; Elementary Education; Learning Processes; *Memory; Mnemonics; *Recall (Psychological); *Retention
IDENTIFIERS *Inference

ABSTRACT

The relationship between retention of story propositions and inferences was studied in two experiments on groups of children who averaged five and eight years in age. In the first experiment, the motives and theme of protagonists were varied and found to affect the number and kind of inferences made by eight-year-olds. The increase in the number of inferences, however, did not affect recall. In the second study on five-year-olds, probed recall was found to be superior to free recall. In both studies, the probability of an inference increased with recall of related propositions, but when the children were matched for retention, the older children made more inferences. Both major results suggest that retention precedes and may be independent of comprehension. (Author)

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Goals, Themes, Inferences, and Memory:

A Developmental Study

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Presented at the 1978 Annual Meeting of

the American Educational Research Association (AERA)

March 27 - 31, 1978

Session 22.16

CS004055

Goals, Themes, Inferences, and Memory: A Developmental Study

A common procedure for measuring comprehension of a text is to ask the person to recall what was heard or read (e.g., Bower, Note 1; Kintsch, Note 2; Mandler & Johnson, 1977; Stein & Glenn, 1978; Thorndyke, 1977). The pervasiveness of this method should rest upon more than its ease of use in experiments. Although seldom stated, the reason for using recall is that what and how much content are recalled are assumed to reflect directly how well the text was represented in memory. This representation, in turn, is a producer of comprehension. For example, in Kintsch's (1976) view, the recall indexes the outcome of macrostructural and microstructural analyses. The former result from the application of knowledge about higher order events in the story schema while the latter lead to a semantic representation of the text base in memory as a set of connected propositions. In this approach, comprehension precedes retention since the retrieval is from a representation that results from comprehension procedures. The degree of recall depends upon how cohesively the propositions are connected in the memory representation as well as the number of propositions and limits in working memory.

The focus of our paper is on the relation between recall and those processes having to do with the construction of a representation of narrative texts. The processes which lead to this construction we shall refer to as "inferencing" and we borrow from Schank (1975) to illustrate what we mean by the term. An inference is "slot-filling" if it generates propositional content not explicit in the text; it is "text-connecting" if it generates relations between propositions which are directly expressed in the text. We have found these distinctions useful in analyzing narratives as chains of events (Warren, Nicholas, & Trabasso, 1978) and have identified a number of

possible inferences in terms of the functional relations between events. Three kinds of relations are of interest: logical (e.g., motivation, enablement, psychological cause, and physical cause), informational (e.g., spatial-temporal relations, pronominal, and lexical reference), and evaluative (e.g., moral and social judgment). The relation identified between events depends upon the classification of the event in terms of its content (e.g., a goal motivates an action; money enables an action, etc.). When a person makes an inference, he uses the content of the events given in the narrative, his knowledge about these events in general, and his working memory to link or fill in events in the chain. The event chain, once constructed, serves as a representation of the narrative which is stored for subsequent recall and further processing.

There have been few direct studies on the relation between memory and inferences (Trabasso & Nicholas, in press). In order to construct a relation between events or to link propositions, it seems necessary that the person would have to hold the surface information of the narrative in memory long enough to construct the links. This may be illustrated with reference to work on transitive inferences of the following form by Trabasso and his colleagues (Trabasso, 1977):

(1) John is smarter than Fred.

(2) Fred is smarter than George.

(3) Who is smarter, George or John?

In order to arrive at the relation between the arguments, John and George in answer to the question posed in (3), retention of the propositions contained in the premises (1) and (2) seem necessary. Trabasso (1977) reviews a number of studies on children and adults where measurement of retention of the premises was made concurrent with measurement of the inference. The correlation be-

tween retention of the premises and the transitive inference is very high and positive (e.g., in one set of 29 conditions, $\underline{r}$ = .80). In addition, the use of reaction-time measures showed that the inference times were faster than those on the premises, indicating that a linear ordering of the arguments was used as a representation in memory and to retrieve information on the original premises and to answer transitive inference questions.

In the studies summarized by Trabasso (1977), the degree of retention of the premises was not only correlated with the number of correct inferences but it was also correlated with age. This confound is unfortunate since the developmental data might have been of use to decide the direction of the relation between retention and inferencing, and subsequent recall. If children of different ages retain premises equally well but the older children and adults make more inferences, then one would have evidence that memory is necessary but not sufficient for comprehension.

Paris and Upton (1976) have also studied the relation between memory for prose content and inferences by children. They found that retention of adjectives, prepositions, nouns, and verbs increased with age as did the number of spatial-temporal inferences. Using the memory scores as a covariate, the number of inferences was still found to increase with age. The conclusion that inferences increase with age independent of the degree of retention depends upon the relation between what was measured in retention and the inferences as well as the kind of quantitative relationship that exists between the measures. In the Paris and Upton (1976) study, the memory measures were not by content and the inference curves were non-linear with age. Thus the question of event memory, inferences, and development are left open.

Kintsch and Vipond (in press) have proposed a model which allows for the interaction of memory and comprehension processes. In their model, a number of propositions from the representation of the text are taken into working memory and a limited number are retained in working memory for further processing. What is retained depends upon how recent and how high in the representational hierarchy a proposition occurs. Note that the propositional representation of the text is assumed to have been derived prior to operations on the text in memory. We find it difficult to understand how this representation could be derived before one has operated upon the text in memory. In other words, it appears to us that comprehension, in the sense of deriving the propositional representation, occurs before any processing in with memory is allowed. In our view, working memory would consist of taking in information from the text, operating upon it, using prior knowledge from long-term memory, deriving the propositional representation and storing this in long-term memory. Limits on either the size of working memory or the knowledge base used to process the information in working memory then could lead to failures to comprehend, i.e., construct the representation and consequently subsequent poorer retrieval. We shall attempt, in the present study, to provide direct evidence on this issue by controlling for retention of premises by children of different ages and making developmental comparisons on inferences.

It should be clear from the above discussion that since inferences are made in constructing the propositional representation which is stored in memory, then inferences aid retention. This assumption seems to be widely shared. For example, in Schank and Abelson (1977), the generation and selection of scripts during comprehension of stories is determined by how well the listener or reader infers the plans of the protagonist. Plans, in turn, are inferred from goals or dispositional themes (traits, social roles, interpersonal relations).

In our experiments, we examine two implications of this view, namely that stories which vary goals or themes should lead to different inferences and that those stories which omit goals and themes should result in less script generation and hence fewer inferences and possibly, less good recall.

Bower (Note 1), in a study on college students, has tested some of these implications. The students read five episode stories about common activities such as going to a doctor or shopping and then were tested for recall one day later. The stories varied as to the stated roles of the protagonists and which goals one could infer from these states. For example, the protagonist was only named or was described as an underweight wrestler or a woman with an unwanted pregnancy. In recall, those students who knew the protagonist's roles recalled more propositions and made more and different spontaneous inferences than those who knew only the protagonist's name.

In designing our materials, we were influenced by Bower's (Note 1) general procedures and attempted to extend them to 5- and 8-year-old children. In our experiments, we used stories which had ambiguous sections that could best be interpreted by knowing the goals of the protagonist. In the first experiment on 8-year-olds, there were three versions of each of three stories. In one version, the motives and referents are left ambiguous; in the other, the motives and theme were either socially desirable (positive) or undesirable (negative). Recall of the stories and inference questions followed. Our second experiment extended these procedures downward in age to 5-year-olds and compared a more sensitive, probed recall procedure with free recall measures of retention. Again, inferences were questioned and related to those propositions in the story upon which they semantically depended. Together, these two experiments allow an examination of the issues discussed above on age, retention, and inferences.

Experiment 1

Methods

Children. Thirty-six children were randomly recruited from a third grade of a public elementary school in St. Paul. The children ranged in age from 8 years, 6 months to 9 years, 5 months with a mean age of 8 years, 10 months. The children were irregularly assigned to one of three experimental conditions with the constraint that half of the children in each condition were boys.

Materials. Three stories, called Toy, Picture, and Fish, were constructed. Each story consisted of two parts: a setting and a core. The core was constructed to be ambiguous as to referents and motives of the main protagonist. For example, as one can see in Table 1, in the core of the Toy story, it is unclear as to where Nancy is located, what she wants, what she is pointing to, why she hides behind the door, and who Fred is. These ambiguities are resolved in two of the three versions of the settings. In the negative and positive settings, the protagonist's motivation and location as well as referents for core lexical and pronominal terms are supplied. In the neutral setting, this information is not present. For example, in Table 1, under the negative and positive settings, Nancy's motivation is clear and contrasting whereas in the neutral condition there is no clear relation between her actions described in the setting and those described in the core story.

Insert Table 1 about here

The Toy, Picture, and Fish stories each contrasted three settings labeled negative, positive, and neutral. The kind of contrast within these rubrics, however, varied. In the Toy story, the protagonist has negative or positive motivation, namely to buy something for herself or for another person. In

addition, in the negative setting she steals the money from her brother's bank. In the Picture story, the protagonist either steals someone else's school work and claims it as her own or does her own school assignment. In the neutral version of the Toy and Picture stories, it is unclear as to where or who the protagonists are and as to why and what the protagonists did (see, for example, Table 1). In the Fish story, the contrast is between having one's expectation fulfilled or disrupted. In the negative version, the protagonist expects to go fishing with his father and an unexpected visitor arrives. In the positive version, the protagonist expects the visitor and includes him in his activity. In the neutral version, it is not stated what the protagonist expected to do. Each version of a story had approximately the same number of words, main and subordinate clauses, and an attempt was made to keep these numbers equal across stories.

Inference Probes. In order to assess whether the children could integrate the setting information with that contained in the subsequent core, a set of probe questions on inferences was constructed for each story. There were 12, 12, and 13 such questions for the Toy, Picture, and Fish stories respectively. Each of these sets contained two types of probes: Between-Probes which required the children to integrate setting information with information in the core story and Within-Probes which could be answered with either setting or core information alone. For negative settings there were 7, 7, and 7 Between-Probes for the Toy, Picture, and Fish stories respectively. There were 8, 8, and 6 such questions for the positive settings and 4, 7, and 2 such questions for the neutral settings. The remaining probes in each condition were Within-Probes. To illustrate, all the inference probe questions for the Toy story are listed in Table 2 along with the propositions of the story judged critical to making the inference and a classification of the inference according to the taxonomy of Warren, Nicholas, and Trabasso (1978).

Insert Table 2 about here

In Table 1, it can be seen that propositions 1-5 describe the setting and propositions 6-16 describe the core. If an inference required information from propositions within either the setting or the core, it was classified as a Within-Probe. If the inference required propositional content across the two sets, it was classified a Between-Probe. For example, Question 9 required propositions 6 and 9 and is therefore a Within- (core story) Probe; Question 10 required proposition 5 from the setting and proposition 13 from the core and was classified as a Between-Probe. The inference questions required the child to either connect propositions or to fill in information between or beyond propositions. For example, in Question 5 of Table 2, the negative and positive settings provide information which allows the child to infer why Nancy wanted the box. The child may do this by identifying the box (proposition 13) with what was on the shelf (proposition 6) in turn with the skateboard which was what Nancy wanted (proposition 2). This series of operations is not possible in the neutral version because the referent of what is on the shelf is not supplied in proposition 2. Here, the child may fill in or elaborate, i.e., make a plausible inference, but such inferences are not constrained by the text. The answers to Question 5 in the negative and positive versions are, however, constrained by the text. Each child was asked the probes in a random order. Four random orders were used in each condition.

Procedure

Each child was assigned to either the negative, positive, or neutral setting condition. All the children heard all three stories under the appropriate setting. The children heard via headphones a cassette tape-recorded version of the stories. The core recording of each story was identical for each condition.

For each story, the child was told that he or she would listen to a story on the tape recorder through headphones and would be asked to tell it back to the experimenter. After listening to a story, the child was asked to recall it as well as possible. Following recall, the child was asked the set of inference probe questions. Then, the child was asked to recall the story again. This procedure was repeated for each story. Each child participated in two sessions. In the first, two stories were presented in the manner described above; the third story was presented in the second session. The first session required approximately one half-hour; the second, 15 minutes. The order of presentation of the stories was counterbalanced over subjects in each condition. The child's responses were tape recorded and subsequently transcribed.

Results and Discussion

Integration of Text

The answers to the questions on inferences were classified as text-constrained, plausible, or other, that is, answers inconsistent with the text and failures to respond. A text-constrained answer meant that the response could be derived from one or more propositions in the text. A plausible answer is one that is consistent with one's knowledge of the world but is not derivable from the text. For example, in the neutral version of the Toy story, the answer "Fred is a bully," to the question, "Why did Nancy hide behind the door when she saw Fred?" is plausible but not text constrained. Two independent judges rated the answers and the interrater agreement was 94%.

Text-constrained inferences. If the children integrate information across propositions, then one should find more constrained answers in the negative and positive setting conditions. The proportion of constrained answers given by a child for each story was obtained and analyzed in an analysis of

variance with story, sex, and setting as factors. The only reliable main effect was that for setting, $F(2,30)$, $p < .01$. The respective proportions of these answers were .77, .60, and .42 for the negative, positive, and neutral settings. No other main effects or interactions were reliable.

A similar analysis was performed separately on Between- and Within-Probe questions. It was anticipated that only the Between-Probes would differentiate the settings. Contrary to these expectations, both types of probes yielded the same pattern of results. For the Between-Probes, a reliable setting effect, $F(2,30) = 30.24$, $p < .01$, was obtained. The respective proportions of the negative, positive, and neutral settings were .80, .60, and .24. Within-Probes also yielded a reliable setting effect of $F(2,30) = 8.34$, $p < .01$. The respective proportions of constrained answers to these probes were .72, .59, and .48.

Plausible inferences. Plausible answers do not depend on the integration of different parts of the text. Consequently one would expect more of this type of inference in the neutral condition since fewer constrained inferences were possible there. This proved to be the case. The proportion of plausible answers given to all the probes by a child for each story was obtained and analyzed by an analysis of variance with story, sex, and setting as factors. There was a reliable setting effect $F(2,30) = 10.61$, $p < .01$, with respective proportions of plausible answers for the Toy, Picture, and Fish stories of .15, .19, and .27. The same pattern of results was obtained for the Between-probes which yielded a significant setting effect of $F(2,30) = 26.10$, $p < .01$. The respective proportions of plausible answers for the three stories were .11, .17, and .35. When the Within-Probes were analyzed, however, there were no reliable differences between the three settings. The respective proportions of plausible answers were .21, .22, and .24.

An important implication of these results is that since the children in the neutral condition answered a substantial proportion of the probe questions with plausible answers, their overall proportion of inferential answers, either constrained or plausible, was high. The respective combined proportions of constrained and plausible answers to the inferential questions for the negative, positive, and neutral conditions were .92, .79, and .69. There was, however, a reliable difference among these means, $F(2,30) = 16.87$, $p < .01$.

Qualitative differences among inferences. In addition to the quantitative results described above, two types of qualitative differences in the answers to the inference probes are of interest. The first addressed the question of whether answers to the inference probes in the negative and positive setting conditions were qualitatively different. In order to assess this, the answers given by children in the positive setting condition to the 18 inference probes capable of differentiating the settings were scored by negative inference criteria. The proportion of constrained answers was .09 as contrasted with .54 when the answers were scored by positive setting criteria.

The second qualitative difference of interest addressed the question of whether there were consistent differences in the number of constrained answers given to different types of probe questions. The inference probes were classified according to the taxonomy provided by Warren, Nicholas, and Trabasso (1978). The proportion of constrained answers for each type of inference probe is given in Table 3. In order to see if there were consistent differences

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Insert Table 3 about here

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between the types of inferences, a rank-order correlation was obtained on the proportion of constrained answers for the two settings. The correlation was not significant, $r = -.15$, $p < .05$. The only consistent, high proportion within

the two conditions are those associated with the pronominal reference inferences. Since these inferences require connecting only two propositions and occur close in the text, this finding is not surprising. The failure to find a correlation across conditions suggests that processing differences with respect to difficulty occurs within types.

Recall of Propositions

The positive and negative settings provided information that resolved the ambiguity of the core story. It was anticipated that recall of story content in these conditions would be greater than in the neutral condition. If children integrated information across the setting and core story in order to resolve ambiguity, structural relations among the propositions would be constructed, and retrieval would be facilitated. Contrary to these expectations, there were no differences in the number of propositions recalled across the three settings. An analysis of variance was performed on the number of propositions that appeared in each child's recall of each story with setting, sex, story, and recall (first and second) as factors. In addition, analyses of variance were performed on the proportions of setting propositions and on the proportions of core story propositions that appeared in these recalls. In all three analyses, there were no setting effects.

These analyses also yielded another null result of interest, namely that there was no difference between the first and second recall of the stories. Thus for the stories used here, at least, there was no evidence that asking inferential questions had an effect on the subsequent recall of the story content.

Inferential Changes in Recall

If a child integrates information between propositions, one would expect that inferences would appear in recall as well as in answers to inferential

questions. Consequently, the number of inferential changes in each recall of each child was obtained. An inferential change referred to either: (1) replacing part of a proposition with different implied semantic content such as replacing "Nancy went into Fred's room" with "Nancy went into her brother's room;" (2) adding implied semantic content to a proposition, such as replacing "Nancy saw Fred" with "Nancy saw Fred walking down the street;" and (3) adding implied propositions such as replacing "he handed her a box" to "Nancy paid the man when he handed her the box." Only inferential changes that were constrained by the text were included; paraphrases such as changing "money in her purse" to "money in her pocketbook" were not included. An analysis of variance was performed on the number of inferential changes that appeared in each recall of each story given to each child; setting, sex, story, and recall (first and second) were entered as factors. The results of this analysis revealed no discernable pattern of inferential changes across settings.

There was also a predictable effect of more inferential chances during the second recall $F(1,30) = 124.43$, $p < .01$. The respective mean number of inferential changes for the first and second recall were 4.1 and 5.8. These results are important because they suggest that the inferential questions did have an effect on the children's subsequent representation of the stories. However, since there was no difference in the proportion of propositions recalled between the two recalls, this effect appears to be limited to adding implied semantic information to that representation rather than affecting the recall of the story per se.

Recall of Premises

A central question here is the relationship between children's ability to generate inferences and to remember the portions of the text critical for generating those inferences. Propositions whose semantic content was

judged to be necessary and sufficient to generate a text-constrained inference was identified for each inference probe. These propositions are hereafter referred to as "premises." For example, in Table 1, the propositions, "Nancy wanted to buy a skateboard for herself," "Nancy saw what she wanted on the shelf," and "she pointed to it," were identified as the premises of the probe "What did Nancy point to?" The number of premises for each probe question ranged from 1 to 5 with an average of 2 per probe.

Analysis of these premises revealed that their recall did not vary with setting condition. An analysis of variance was performed on the proportion of propositions for each story that was identified as the premise of at least one inference probe. Since we were interested in a child's recall of the premises that presumably would be used to answer the inferential questions, only premises appearing in the first recall were analyzed. The setting, sex, and story were entered as factors. This analysis revealed no reliable setting effect. The respective proportion of premises recalled in the negative, positive, and neutral settings were .59, .54, and .62.

In order to validate, in part, our identification of those premises which were related to making an inference, we calculated the probability of making a constrained answer to an inference probe for each percentage of possible premises recalled. The percentages ranged from 0 to 100 in 11 different intervals depending upon the number of premises related to the inferences and their percentage recalled.

The probability of making an inference increased with recall of the premises, over all settings, $r = .72$, $p < .01$. This and the other setting relations are summarized in Table 4 where we collapsed the percentages of premises recalled

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Insert Table 4 about here

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into quartiles and calculated the probability of an inference for each quartile of premise recall. The fact that inferences increased with recall of the premises for all three settings indicates that they are related and that our identification of the relation is valid.

Experiment 2

Methods

Children. Thirty-six children were recruited from a kindergarten of a public elementary school in St. Paul. The children ranged in age from 5 years, 9 months to 6 years, 5 months, with a mean of 6 years, 1 month. The children were irregularly assigned to one of two conditions with the constraint that half of the children in each condition were boys.

Materials

Stories. The negative version of the Toy and Picture stories of Experiment 1 were used, and were presented via cassette recording.

Text probes. Half of the children had their retention of the stories assessed by text probes; the other half recalled the story as in Experiment 1. The probes queried specific propositions judged critical to answering the inference questions. For example, among the text probes for the Toy story which are depicted in Table 5, the probes "What did Nancy want for herself?," "Where was the thing that Nancy wanted?," and "What did the man give to Nancy?" require the child to retrieve that Nancy wanted a skateboard, that it was on the shelf, and that the man handed her a box. This information was judged to be necessary

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Insert Table 5 about here

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to answer the inference probe, "Why did Nancy want the box?" There were 16 text probes each for the Toy and Picture stories. The probes were asked in the same order as their related propositions appeared in the text (see for example, their order in Table 5).

Inference probes. The same inference questions described in Experiment 1 were used except those about spatial-temporal relations (Questions 10-13, Table 2) which were deleted. The inference probes were asked in four different orders across subjects within each condition.

Procedure

Half of the children were irregularly assigned to a probed-recall condition; the remaining children were assigned to a free-recall condition. For each story, children in the probed-recall condition listened to the stories in the same manner described for Experiment 1. After listening to a story, these children were asked the probe questions on the text. Children in the free-recall condition also listened to the stories in the same manner described for Experiment 1. After listening to a story, these children were asked to recall to recall the story. All children were asked the inference probe questions following probe or free recall. Each child participated in a single half-hour session. Half of the children in each condition heard the Picture story first; the remaining children heard the Toy story first. As in Experiment 1, the children's responses were recorded and subsequently transcribed for analysis.

Results and Discussion

Premise Retention

In the probed-recall condition, the text probes directly queried information judged necessary and sufficient to generate a text-constrained inference. The answers to these questions were scored as correct if they contained the relevant arguments of the proposition queried. The protocols of the free-recall condition were scored for the number of these premises recalled in the same manner as that used for Experiment 1. As anticipated, the probed groups retrieved more premises than the free recall group; the respective proportions correctly recalled were .84 and .56. This difference was found to be statis-

tically significant, $F(1,28) = 20.27$, $p < .01$. In an analysis of variance with condition, order, sex, and story as factors, no other main effects were significant.

Inferences

We examined whether the method of assessing retrieval affected the number and kind of inferences made. The answer to this question is negative. The proportions of constrained, plausible, or both kinds of inferences were compared for the two recall conditions and no statistically reliable differences were found. This null effect was also obtained in separate analyses on probes both within and between story units. The mean proportions of these comparisons are summarized in Table 6.

Insert Table 6 about here

Qualitative Differences among Inferences

The inference probes were classified by the Warren, Nicholas and Trabasso (1978) taxonomy and the resulting mean proportions of constrained answers are given in Table 7.

Insert Table 7 about here

The two conditions yielded comparable levels and rank orders of inference answers. The rank order correlation between the two conditions was .87 ($p < .05$). However, the condition of recall had no discernable effect on the number and kind of inference made.

Inferences and Premises

As in Experiment 1, the probability of a constrained inference for different degrees of recall of the premises was computed for each inference probe. The overall retrieval of the premises was also highly correlated with the inference probabilities, $r = .80$, $p < .01$, and validates the judgment of these propositions as necessary to making the inferences. The respective rank-order correlations (n = 11 proportions) for the recall and probe conditions were .72 and .68 ($p < .05$). The probabilities for each quartile of free recall were .27, .59, .67, and .65; for the probed recall, .15, .31, .45, and .73.

Age Comparisons

The children who had the Picture and Toy stories under the negative setting condition provide a basis for comparison across ages and the two experiments. We shall examine these age effects with respect to inferences made, recall of propositions and the relationship between the inferences and premise recall.

Inferences. The most direct age comparison is between the free recall condition of Experiment 2 with Experiment 1. The two age groups were compared on the number of either constrained or plausible inferences. The 8-year-old children made more inferences to both Between- and Within-Probes, $F(1,26) = 11.85$, and 4.24 respectively, $p < .05$. When constrained and plausible inferences were analyzed separately, the difference between the age groups was found only for the constrained answers, $F(1,26) = 11.60$ and 6.12, $p < .05$. The mean proportions of these comparisons are given in Table 8.

Insert Table 8 about here

Recall. As was anticipated, the 8-year-old children recalled more total propositions than did the 5-year-olds, $F(1,26) = 7.81$, $p < .01$. There was not, however, a reliable difference between the two age groups on the recall of propositions identified as premises. The 8-year-olds also made more constrained inferential changes in their recalls than did 5-year-olds, $F(1,26) = 12.59$, $p < .01$. The means and proportions of these comparisons are given in Table 9.

Insert Table 9 about here

Inferences and premises. We found above that 8-year-old children made more constrained inferences than did 5-year-old children. One can match these groups for memory of the premises by comparing these two age groups on the probability of inferences for each quartile of premise retrieval in order to assess inferential ability independent of recall.

We equated all the 5- and 8-year-olds on the proportion of premises recalled and compared them on the probability of an inference for each of the 11 resulting proportions by a sign test. Although the two 5-year-old groups did not differ from one another, the 8-year-olds made significantly more inferences ($p < .01$) in both comparisons. These data are summarized by quartiles of premises recalled and their corresponding probabilities of inferences for the combined 5-year-old data and that of the 8-year-olds in Figure 1. As

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Insert Figure 1 about here

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can be seen, 8-year-olds made more inferences even though the children were matched for recall of the premises. These data suggest that the ability to make inferences improves with age over and above independent of differences in

memory of the text.

General Discussion

The data in both experiments indicate that retention and inferencing may be independent. Although we were successful in producing more and different inferences in Experiment 1, recall was not facilitated. Since the children who had clear and contrasting motivation and theme information produced more constrained and plausible inferences, we should have found retention differences if inferencing leads to a more cohesive memorial representation of the text. Thus we failed to extend Bower's (1976) finding and to provide support for the assumption that comprehension precedes or underlies recall. Our conclusion may be limited to differences in experiments and possible ceiling effects. We might have found differences in recall had we used more complicated stories or delayed testing of retention for a day as did Bower (1976).

However, the developmental comparisons also support the interpretation that retention may precede and be independent of inferencing. While we found that the number of inferences made increased with the number of premises retrieved, replicating both Trabasso's (1977) and Paris and Upton's (1976) findings on children, we found that when we matched the 5- and 8-year-old children for retention of the premises, the older children made more inferences for all levels of retention, a result also in line with Paris and Upton's (1976) conclusion. It would appear, then, that given equal limits on memory as indexed by retrieval of propositions, the older children have a greater knowledge of the world which serves as a basis for making inferences than do the younger children. Although some younger children are able to retain as much of the propositional content as well as their older counterparts, they do not construct as cohesive a propositional structure. The differences in understand-

ing of the propositional representation generated in the memory model of Kintsch and Vipond (in press) are assumed to result from limits in working memory rather than differences in knowledge and ability to make inferences. Our data suggests that the differences in what children know and can relate at a semantic level of analysis may be as critical as memory limits.

The use of free recall as a measure of comprehension is also under question here. The comparison of free with probed recall in Experiment 2 indicates that although the procedures did not differentially affect inferences, free recall clearly underestimated what the children knew about the stories. This conclusion is also supported by Stein and Glenn's (1978) second experiment where they asked a series of Why questions on every propositional category and found that the younger children gave more and different information about propositional content, especially on internal states (goals and affect) of protagonists than was revealed by the free recall data of their first experiment. In a like manner, if inferencing as measured by our questions is an index of comprehension, then we have shown that comprehension can occur independent of recall by the use of a developmental study.

Reference Notes

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Footnote

This research was supported by National Institute of Education Grant Number NIE-G-77-0018 to T. Trabasso, by USPHS, National Institute of Mental Health Grant Number 29365 to T. Trabasso, by a National Institute of Child Health and Human Development program project grant (5 P01 HD05027) to the University of Minnesota's Institute of Child Development, and Center for Research in Human Learning (HD01136), and by a grant from the National Science Foundation to the Center (GB-17590). The second author is now at the University of Connecticut, Storrs, Connecticut. Requests for reprints should be sent to Tom Trabasso, Institute of Child Development, University of Minnesota, 51 East River Road, Minneapolis, Minnesota 55455.

Table 1

Negative, Positive, and Neutral
Versions of the Toy Story

	Negative Setting	Positive Setting	Neutral Setting
1.	Nancy didn't have any money in her purse.	Nancy didn't have any money in her purse.	Nancy didn't have a handkerchief in her purse.
2.	Nancy wanted to buy a skateboard for herself.	Nancy wanted to buy a skateboard for her brother Fred.	Nancy wanted to have one for her cold.
3.	She went into Fred's room	She went into her room	She found one in her pocket
4.	and emptied her brother's piggy bank into her purse.	and emptied her piggy bank into her purse.	and put it in her purse.
5.	Nancy went to the store.	Nancy went to the store.	Nancy went across the room.

Core Story

6. Nancy saw what she wanted on the shelf.
7. When the man came over,
8. she pointed to it.
9. She accidentally knocked over a lamp.
10. The lamp fell with a crash.
11. Nancy said she was sorry.
12. The man said it was O.K.
13. He handed her the box.
14. As she was walking out,
15. Nancy saw Fred.
16. Nancy hid behind the door.

Table 2

Critical Propositions and Taxonomic Classification of Inference Probes

Inference Probe	Critical Propositions			Inference Type		
	Negative	Positive	Neutral	Negative	Positive	Neutral
1. What do you think happened next?	--[a]	--[a]	--[a]	Elaborative	Elaborative	Elaborative
2. Who is Fred?	3,4	--[b]	15	Referential	Given	Elaborative
3. What did Nancy point to?	2,6,8	2,6,8	6,8	Referential/ Pronominal	Referential/ Pronominal	Elaborative
4. Did Nancy give the man something?	5,13	5,13	--[b]	Enablement/ World frame	Enablement/ World frame	Elaborative
5. Did the man see Nancy knock over the lamp?	7,9,11	7,9,11	7,9,11	Enablement	Enablement	Enablement
6. Why did Nancy want the box?	2,6,13	2,6,13	6,13	Referential/ Pronominal	Referential/ Pronominal	Pronominal
7. Why did Nancy hide behind the door?	2,3,4, 15,16	2,6,13, 15,16	15,16	Motivational	Motivational	Motivational
8. How did Nancy feel when she saw Fred?	2,3,4, 15	2,6,13, 15	15	Psychological cause	Psychological cause	Psychological cause
9. Is Nancy honest?	2,3,4	--[a]	--[a]	Evaluative	Evaluative	Evaluative
10. Where was the lamp that Nancy knocked over?	6,9	6,9	6,9	Spatial-temporal	Spatial-temporal	Spatial-temporal
11. Where was Nancy when she got the box?	5,13	5,13	5,13	Spatial-temporal	Spatial-temporal	Spatial-temporal
12. How long did Nancy have the box before she saw Fred?	13,14, 15	13,14, 15	13,14, 15	Spatial-temporal	Spatial-temporal	Spatial-temporal
13. Had Nancy gotten what she wanted before she knocked over the lamp?	6,9,13	6,9,13	6,9,13	Spatial-temporal	Spatial-temporal	Spatial-temporal

[a] Critical propositions not identifiable because entire story is needed to answer probe. Probe is classified a Between Probe.

[b] Critical propositions not identifiable because answer is contained in text. Probe classified a Within Probe.

Table 3

Proportion of Constrained Inferences

for Different Kinds of Questions by 8-year-olds

Inference	Number of questions	Setting	
		Negative	Positive
Causal			
Motivation	4	.79	.75
Psychological	5	.88	.50
Enablement	4	.79	.68
Informational			
Pronominal	3	.94	.85
Referential	4	.81	.62
Spatial-temporal	12	.72	.65
World frame	3	.83	.41
Evaluative	2	.88	.58
	37		

Table 4

Probabilities of Constrained Inferences

for Different Degrees of Premise Retrieval

	Percentage of premises recalled			
	Quartile			
Setting condition	1	2	3	4
Negative	.60	.71	.84	.88
Positive	.48	.58	.66	.86
Neutral	.32	.31	.45	.41
All settings	.46	.55	.68	.69

Table 5

Toy Story Probes for Experiment 2

	Propositions	Text Probe
1.	Nancy didn't have any money in her purse	
2.	Nancy wanted to buy a skateboard for herself.	What did Nancy want for herself?
3.	She went into Fred's room	Where did Nancy go to get the piggy bank?
4.	and emptied her brother's piggy bank into her purse.	Whose piggy bank was it?
5.	Nancy went to the store.	Where did Nancy go next?
6.	Nancy saw what she wanted on the shelf.	Where was the thing that Nancy wanted?
7.	When the man came over,	
8.	she pointed to it.	What did Nancy do when the man came over?
9.	She accidentally knocked over a lamp.	
10.	The lamp fell with a crash.	
11.	Nancy said she was sorry.	What did Nancy say after she knocked over the lamp?
12.	The man said it was O.K.	What did the man say?
13.	He handed her the box.	What did the man give to Nancy?
14.	As she was walking out,	
15.	Nancy saw Fred.	Who did Nancy see as she was walking out?
16.	Nancy hid behind the door.	Then what did Nancy do?

Table 6

Comparison of Kinds of Recall on Inferences

	Proportion of inferences			
	Constrained		Plausible	
Kind of Recall:	Probed	Free	Probed	Free
Story unit				
Between	.56	.47	.17	.17
Within	.50	.46	.26	.29

Table 7

Proportion of Constrained Inferences

for Different Kinds of Questions by 5-year-olds

Inference	Number of questions	Recall condition	
		Probe	Free
Causal			
Motivation	2	.72	.64
Psychological	3	.59	.39
Enablement	3	.44	.35
Informational			
Pronominal	3	.76	.67
Referential	4	.52	.56
World frame	2	.72	.67
Evaluative	2	.56	.61

Table 8

Comparisons of 5- and 8-year-olds on Proportion of Inferences

	Kind of inferences			
	Constrained		Plausible	
Age:	5[a]	8[b]	5[a]	8[b]
Story unit:				
Between	.47	.83	.17	.12
Within	.46	.74	.29	.22

[a]Recall condition only.

[b]First recall of negative setting condition only.

Table 9

Comparison of 5- and 8-year-olds on Recall

Recall item	Age 5[a]	Age 8[b]
Propositions (Proportion)	.47	.66
Premises (Proportion)	.56	.63
Inferential changes (Mean)	4.2	6.8

[a]Free recall condition only.

[b]First free recall of negative setting condition only.

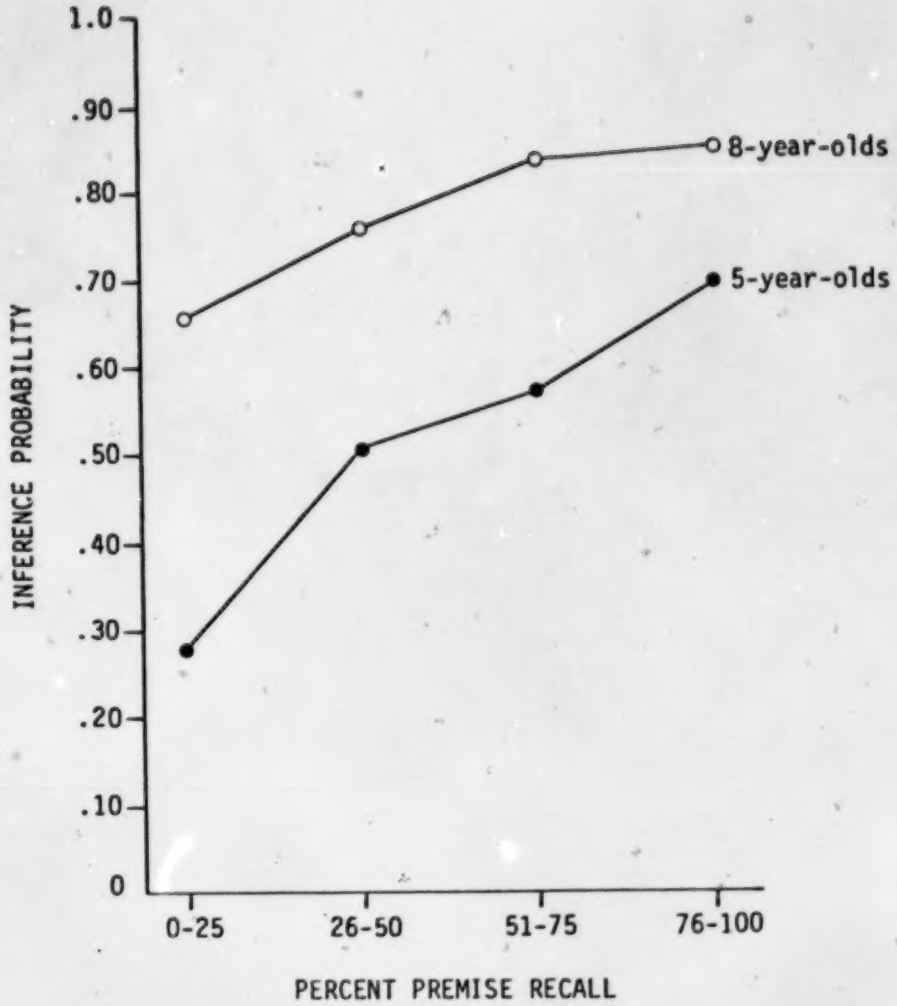
1.0
.90
.80
.70
.60
.50
.40
.30
.20
.10
0
INFERENCE PROBABILITY
8-year-olds
5-year-olds
0-25
26-50
51-75
76-100
PERCENT PREMISE RECALL

FIGURE 1